Technological development for efficient inspection

Toshinori Yasuzato,Hidekazu Kanesawa

Maintenance Engineering Division
West Nippon Expressway Company Limited.
Dojima Avanza 19F 1-6-20 Dojima Kitaku Osaka Japan
t.yasuzato.aa@w-nexco.co.jp

ABSTRACT

West Nippon Expressway Company ltd. (NEXCO West) is one of the intercity tollroad operators in Japan. Recently the environment of expressway operation is considerably changing, such as advancement of damages on highway structures caused by aging, upsizing of vehicles and increase of traffic. Damages on highway structures can cause injury to the public. For bridges and tunnels, spalling of concrete debris is a serious problem, and for pavements, pot holes occasionally occur in spite of periodical rehabilitation.

On the other hand, it is NEXCO-West's social responsibility to offer safety and reliability for expressway users and communities, and ensure high speed driving and punctuality.

When we maintain highway assets, it is important to perform expressway inspect effectively and prevent accidents beforehand and prevent spalling of concrete debris and occurrence of potholes. This paper introduces our effort for efficient inspection methods using infrared camera and high-definition camera.

1. INTRODUCTION

NEXCO-West operates over 3,300km expressways in west region of Japan, composed of 2,340km of cuts and embankments (70%), 590km of bridges (17%) and 430km of tunnels (13%). Figure-1 shows the age of bridges operated by NEXCO-West. The average age of bridges is 21 years. Some of them are more than 40 years old, and aging bridges are increasing year and year.

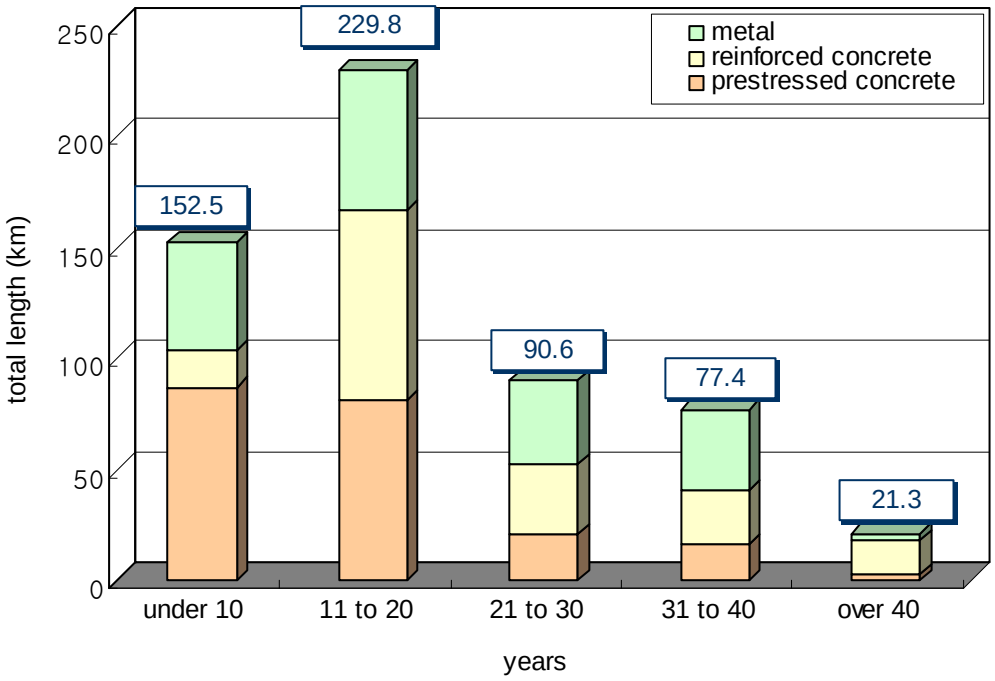


Figure-1. Bridges operated by NEXCO-West

2. Deterioration of road structures

Some of our highway structures are aging, and spalling of concrete debris occasionally happen at bridges and tunnels, and potholes appears in pavements. Those deteriorated structures require repair or rehabilitation works.

According to our experiences, as for bridges, concrete debris tend to spall from the edge of a slab. One of the main reasons for concrete spalling is the corrosion of rebar under the influence of water from road surface and deicing salt (see picture-1).

Picture-1. Concrete spalling from the edge of a slab

As for tunnels, concrete debris tend to spall from a joint of a concrete lining. Mainly, initial defect during under construction work such as lack of compaction of fresh concrete and too much uplift of a centre may cause the spalling of concrete debris (see picture-2).

Picture-2. Concrete spalling from a joint of a concrete lining

As for pavements, many potholes appear because of deterioration of subbases or bridge decks. In some cases potholes repeatedly appear at the same spot in relatively short period of time after repairing.

3. Method of inspection in NEXCO-West

In NEXCO-West, the annual operation and maintenance cost is almost 144bn.JPY, and inspection annual cost is almost 10bn.JPY in 2008. NEXCO-West has been implementing four types of inspection as shown in Table-1.

Table-1. Types of inspection in NEXCO-West

Type	Procedure	Frequency	In Charge
Initial Inspection	Initial conditions of the finished structure are confirmed by close visual inspection and sounding test before opening.	Once before open	Contractors Inspectors from Engineering Companies
Daily Inspection	Visible unusual conditions and deformations of structures are inspected daily from behind the wheels.	Once every two days to Once every four days (Depending on traffic volume)	Maintenance Engineers from Maintenance Companies
Routine Inspection	The condition of structures is regularly checked by distant visual inspection, close visual inspection and sounding test.	More than once a year	NEXCO-West engineers and Group company engineers
Detailed Inspection	The condition of structures is checked by close visual inspection and sounding test more in detail.	Once every five years In some cases, once every ten years	Inspectors from Engineering Companies

NEXCO-West has been inspecting not only to prevent hazards to the third parties caused by deteriorations of road structures but also to evaluate those conditions correctly for the purpose of strategic repair. However, the volume of road structures are huge, and will age year and year; therefore, it is a serious issue that our inspection requires huge man power, cost and time. As a result, a cycle of inspection to prevent hazards to the third parties becomes longer.

4. Effort to Efficient Bridge Inspection

Bridge inspection have been mainly implemented by routine inspection and detailed inspection. However, it is difficult to detect delamination or spalling of concrete without getting close to the bridge deck, and sounding test usually require temporary staging and traffic regulation in order to reach the bridge deck.

In NEXCO-West, efficient inspection using infrared camera has been implemented for bridges that hazards to the third parties may occur by spalling of concrete debris. This inspection for whole bridge deck can contribute to screening of the area of applying sounding test, and furthermore; reduction of time and cost for inspection (see picture-3).

The mechanism of infrared thermography method is as follows. In flawed areas of concrete, the cavity of concrete interior becomes heat insulation as compared with non-dameged areas. While concrete surface temperature is changing in a day because of sunlight or change of air temperature, the period with the temperature difference of concrete surface appearance between areas in sound and flawed condition. In order to detect delamination or spalling of concrete by infrared camera, we utilize this temperature difference as shown in figure-2.

Picture-3. Inspection using infrared camera

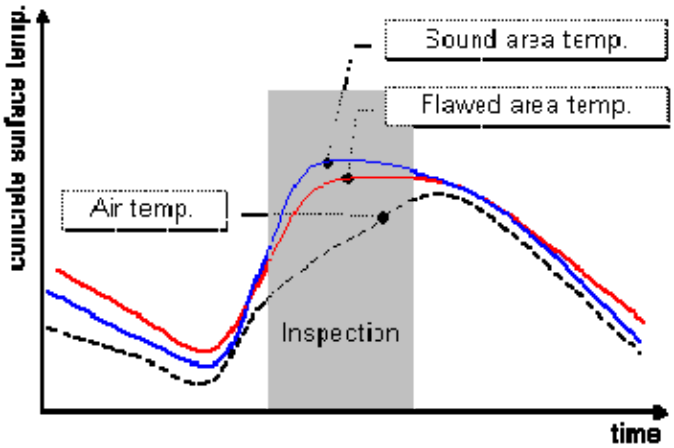
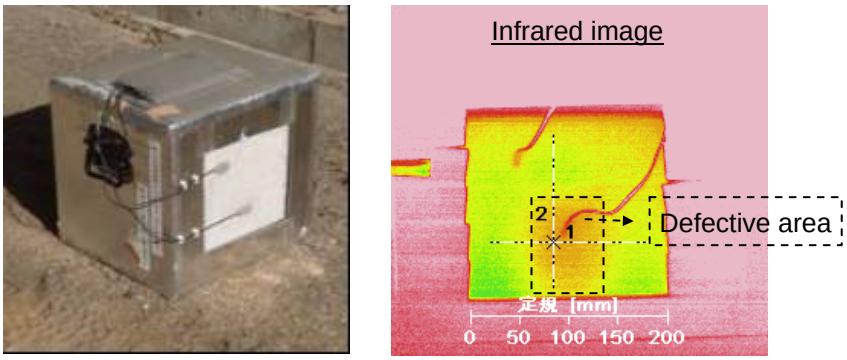


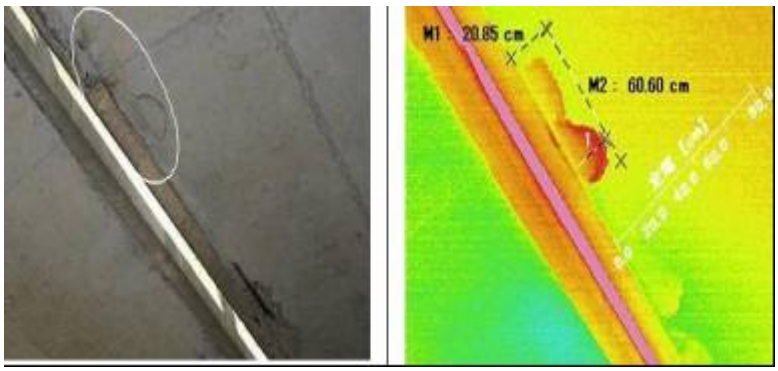
Figure-2. Concrete surface temperature in a day

As for inspection at the filed, the inspector installs the test piece which has artificial void inside the concrete around the bridge before the inspection for whole bridge decks. When the test piece which has artificial void inside the concrete shows the temperature difference as shown in picture-4, infrared camera is ready to be used.



Picture-4. Test piece

Delamination or spalling located within 4cm from the surface is detectable. Picture-5 shows comparison of a visible picture and an infrared one for a delamination in an edge of a slab.



Picture-5. Delamination in an edge of a slab

5. Effort to Efficient Pavement Inspection

Pavement inspection has been mainly implemented by daily inspection from behind the wheel, and in addition, surveys of rutting, crack and International Roughness Index (IRI) have been implemented using road surface condition measurement vehicle once every two years to three years. However, in a conventional approach, we must draw crack distribution sketched on photos in order to appreciate condition of pavement; therefore, this survey have required enormous time and cost.

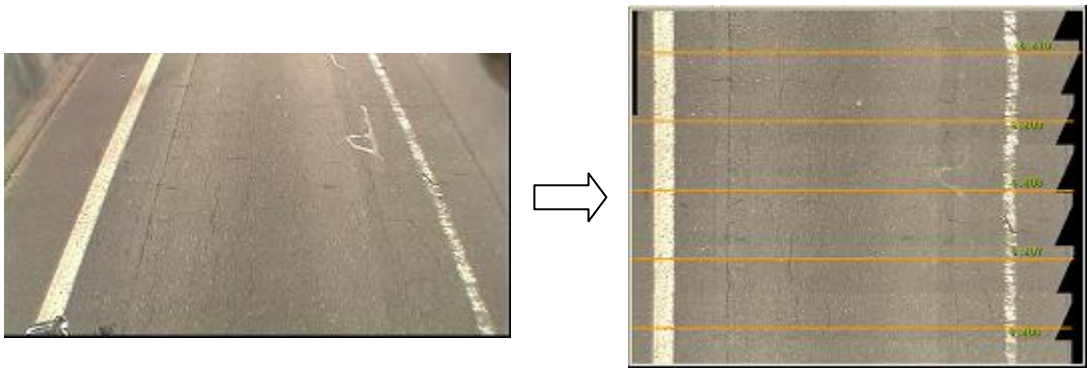
In NEXCO-West, efficient inspection using high-definition camera has been implemented for pavement. This inspection can contribute to detecting cracks automatically and also appreciating condition of pavement, and furthermore; appearance of potholes in advance.

The system detecting cracks of pavement is composed of the GPS navigation system, high-definition camera, and laptop computer, and those are included inside the inspection vehicle as shown in picture-6. Vehicle location

Picture-6. Inspection vehicle

data is obtained from GPS. The high-definition video camera is attached on top of the inspection vehicle to record the surface condition.

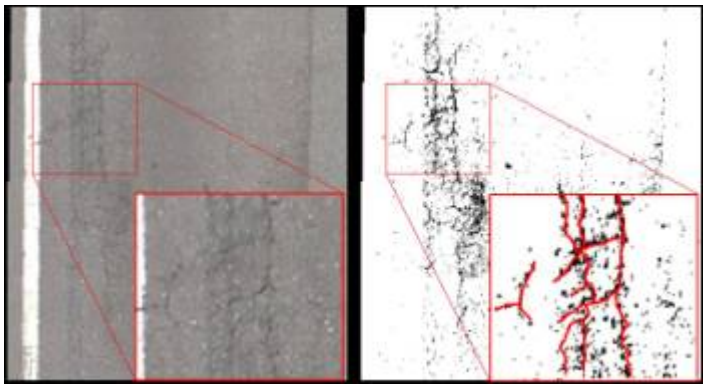
The picture of an asphalt surface as shown in the left side of picture-7, is taken from the angle of 45 degrees by this camera, and then the recorded data is automatically cut and pasted into 2-dimensional database as shown in the right side of picture-7, in order to be used for crack analysis.



Picture-7. Picture of an asphalt surface taken from the inspection vehicle

As for analysis, the picture of asphalt surface is converted into binary data, and crack distribution is automatically drawn as shown in picture-8. This system can detect cracks with about 1.5mm width at 80km/h.

The problem is that accuracy of crack detection is less than perfect, so further improvement in accuracy of inspection is required in the future effort.



Picture-8. Binary data for crack distribution

6. Effort to Efficient Tunnel Inspection

Tunnel inspection have been mainly implemented by routine inspection and detailed inspection, like we do for bridge structures. However, tunnel Inspection under bad condition such as dirty concrete linings and looking upward in exhaust gas have caused deterioration in quality and efficiency.

In NEXCO-West, efficient inspection using high-definition camera has been implemented for tunnels. This inspection can contribute to detecting cracks in surface of a concrete lining, particularly a joint of that concrete fragments tend to fall.

Pictures of concrete linings are taken by the truck equipped with four high-definition cameras, metal

halide lamp for lighting and recording devices as shown in picture-9. Running on a nearside and a passing lane enables to take pictures covering an upper-half lining. This crack detection system can detect cracks with about 0.2mm width at 80km/h.

Picture-9. Truck equipped with devices taking pictures

In the future, development of the software to extract the image of joint part from the concrete lining will be performed, this effort can enable us to decrease inspection period.

7. Conclusion

NEXCO-West will make efforts of efficient inspection to prevent accidents beforehand and prevent spalling of concrete debris and occurrence of potholes in future, and in addition, in order to offer safety and reliability for expressway users and communities, and ensure high speed driving and punctuality, we recognize necessity of efforts such as education of engineers can judge for the result of inspection correctly and development of an appropriate rehabilitation.